WHAT IS CLAIMED IS:

1. A deterioration detection apparatus for an oxygen sensor, comprising:

a first judgment value acquirer that calculates an element impedance real value from a value related to an electric power supplied to the oxygen sensor, and that acquires the calculated value as a first judgment value;

a second judgment value acquirer which calculates an element temperature estimated value of the oxygen sensor from a factor that affects a temperature of the oxygen sensor, and which acquires the calculated value as a second judgment value; and

an abnormality determiner that determines whether the oxygen sensor has an abnormality based on the first judgment value and the second judgment value.

2. The deterioration detection apparatus according to claim 1, wherein the abnormality determiner determines that the oxygen sensor has an abnormality if a relationship between the first judgment value and the second judgment value does not agree with a normal temperature characteristic that is exhibited by an element impedance of the oxygen sensor.

3. The deterioration detection apparatus according to claim 2,

wherein the oxygen sensor comprises a sensor element that exhibits the temperature characteristic, and a heater for heating the sensor element, and

wherein the factor that affects the temperature of the oxygen sensor includes at least a factor related to a state of operation of the heater, and

wherein the abnormality determiner comprises a heater electrification state detector that detects a state of electrification of the heater, and a sensor element abnormality identifier that, if it is determined that the oxygen sensor has an abnormality in a situation where the heater is not electrified, identifies the abnormality as an abnormality of the sensor element.

4. The deterioration detection apparatus according to claim 3, wherein the abnormality determiner comprises an electrification stopper that stops electrification of the heater if it is determined that the oxygen sensor has an abnormality in a situation where the heater is electrified.

5. The deterioration detection apparatus according to claim 4, wherein the abnormality determiner comprises a heater abnormality determiner that determines that the heater has an abnormality if determination of an abnormality of the oxygen sensor is overturned after the electrification of the heater is stopped by the electrification stopper.

6. The deterioration detection apparatus according to claim 1,

wherein the abnormality determiner comprises a first change amount detector that detects an amount of change in the first judgment value, and a second change amount detector that detects an amount of change in the second judgment value, and

wherein the abnormality determiner determines that the oxygen sensor has an abnormality if the amount of change in the first judgment value and the amount of change in the second judgment value do not exhibit a normal correlation.

7. A deterioration detection apparatus for an oxygen sensor, comprising:

a first judgment value acquirer that calculates an element impedance real value from a value related to an electric power supplied to the oxygen sensor, and that acquires the calculated value as a first judgment value;

a second judgment value acquirer which calculates an element impedance estimated value from a factor that affects a temperature of the oxygen sensor, and which acquires the calculated value as a second judgment value; and

an abnormality determiner that determines whether the oxygen sensor has an abnormality based on the first judgment value and the second judgment value.

8. The deterioration detection apparatus according to claim 7, wherein the abnormality determiner determines that the oxygen sensor has an abnormality if a difference between the first judgment value and the second judgment value exceeds a predetermined criterion.

9. The deterioration detection apparatus according to claim 8,

wherein the oxygen sensor comprises a sensor element that exhibits a temperature characteristic, and a heater for heating the sensor element, and

wherein the factor that affects the temperature of the oxygen sensor includes at least a factor related to a state of operation of the heater, and

wherein the abnormality determiner comprises a heater electrification state detector that detects a state of electrification of the heater, and a sensor element abnormality identifier that, if it is determined that the oxygen sensor has an abnormality in a situation where the heater is not electrified, identifies the abnormality as an abnormality of the sensor element.

10. The deterioration detection apparatus according to claim 9, wherein the abnormality determiner comprises an electrification stopper that stops electrification of the heater if it is determined that the oxygen sensor has an abnormality in a situation where the heater is electrified.

11. The deterioration detection apparatus according to claim 10, wherein the abnormality determiner comprises a heater abnormality determiner that determines that the heater has an abnormality if determination of an abnormality of the oxygen sensor is overturned after the electrification of the heater is stopped by the electrification stopper.

12. The deterioration detection apparatus according to claim 7,

wherein the abnormality determiner comprises a first change amount detector that detects an amount of change in the first judgment value, and a second change amount detector that detects an amount of change in the second judgment value, and

wherein the abnormality determiner determines that the oxygen sensor has an abnormality if the amount of change in the first judgment value and the amount of change in the second judgment value do not exhibit a normal correlation.

13. A deterioration detection apparatus for an oxygen sensor, comprising:

a first judgment value acquirer that calculates an element temperature theoretical value from a value related to an electric power supplied to the oxygen sensor, and that acquires the calculated value as a first judgment value;

a second judgment value acquirer which calculates an element impedance estimated value from a factor that affects a temperature of the oxygen sensor, and which acquires the calculated value as a second judgment value; and

an abnormality determiner that determines whether the oxygen sensor has an abnormality based on the first judgment value and the second judgment value.

14. The deterioration detection apparatus according to claim 13, wherein the abnormality determiner determines that the oxygen sensor has an abnormality if a relationship between the first judgment value and the second judgment value does not agree with a normal temperature characteristic that is exhibited by an element impedance of the oxygen sensor.

15. The deterioration detection apparatus according to claim 14,

wherein the oxygen sensor comprises a sensor element that exhibits the temperature characteristic, and a heater for heating the sensor element, and

wherein the factor that affects the temperature of the oxygen sensor includes at least a factor related to a state of operation of the heater, and

wherein the abnormality determiner comprises a heater electrification state detector that detects a state of electrification of the heater, and a sensor element abnormality identifier that, if it is determined that the oxygen sensor has an abnormality in a situation where the heater is not electrified, identifies the abnormality as an abnormality of the sensor element.

16. The deterioration detection apparatus according to claim 15, wherein the abnormality determiner comprises an electrification stopper that stops electrification of the heater if it is determined that the oxygen sensor has an abnormality in a situation where the heater is electrified.

17. The deterioration detection apparatus according to claim 16, wherein the abnormality determiner comprises a heater abnormality determiner that determines that the heater has an abnormality if determination of an abnormality of the oxygen sensor is overturned after the electrification of the heater is stopped by the electrification stopper.

18. The deterioration detection apparatus according to claim 13,

wherein the abnormality determiner comprises a first change amount detector that detects an amount of change in the first judgment value, and a second change amount detector that detects an amount of change in the second judgment value, and

wherein the abnormality determiner determines that the oxygen sensor has an abnormality if the amount of change in the first judgment value and the amount of change in the second judgment value do not exhibit a normal correlation.

19. A deterioration detection apparatus for an oxygen sensor, comprising:

a first judgment value acquirer that calculates an element temperature theoretical value from a value related to an electric power supplied to the oxygen sensor, and that acquires the calculated value as a first judgment value;

a second judgment value acquirer which calculates an element temperature estimated value from a factor that affects a temperature of the oxygen sensor, and which acquires the calculated value as a second judgment value; and

an abnormality determiner that determines whether the oxygen sensor has an abnormality based on the first judgment value and the second judgment value.

20. The deterioration detection apparatus according to claim 19, wherein the abnormality determiner determines that the oxygen sensor has an abnormality if a difference between the first judgment value and the second judgment value exceeds a predetermined criterion.

21. The deterioration detection apparatus according to claim 20,

wherein the oxygen sensor comprises a sensor element that exhibits a temperature characteristic, and a heater for heating the sensor element, and

wherein the factor that affects the temperature of the oxygen sensor includes at least a factor related to a state of operation of the heater, and

wherein the abnormality determiner comprises a heater electrification state detector that detects a state of electrification of the heater, and a sensor element abnormality identifier that, if it is determined that the oxygen sensor has an abnormality in a situation where the heater is not electrified, identifies the abnormality as an abnormality of the sensor element.

22. The deterioration detection apparatus according to claim 21, wherein the abnormality determiner comprises an electrification stopper that stops electrification of the heater if it is determined that the oxygen sensor has an abnormality in a situation where the heater is electrified.

23. The deterioration detection apparatus according to claim 22, wherein the abnormality determiner comprises a heater abnormality determiner that determines that the heater has an abnormality if determination of an abnormality of the oxygen sensor is overturned after the electrification of the heater is stopped by the electrification stopper.

24. The deterioration detection apparatus according to claim 19,

wherein the abnormality determiner comprises a first change amount detector that detects an amount of change in the first judgment value, and a second change amount detector that detects an amount of change in the second judgment value, and

wherein the abnormality determiner determines that the oxygen sensor has an abnormality if the amount of change in the first judgment value and the amount of change in the second judgment value do not exhibit a normal correlation.

25. A deterioration detection method for an oxygen sensor, comprising the steps of:

calculating an element impedance real value from a value related to an electric power supplied to the oxygen sensor, and acquiring the calculated value as a first judgment value;

calculating an element temperature estimated value of the oxygen sensor from a factor that affects a temperature of the oxygen sensor, and acquiring the calculated value as a second judgment value; and

determining whether the oxygen sensor has an abnormality based on the first judgment value and the second judgment value.

26. The deterioration detection method according to claim 25, wherein, in the abnormality determining step, it is determined that the oxygen sensor has an abnormality if a relationship between the first judgment value and the second

judgment value does not agree with a normal temperature characteristic that is exhibited by an element impedance of the oxygen sensor.

27. The deterioration detection method according to claim 26,

wherein the oxygen sensor comprises a sensor element that exhibits the temperature characteristic, and a heater for heating the sensor element, and

wherein the factor that affects the temperature of the oxygen sensor includes at least a factor related to a state of operation of the heater, and

wherein the abnormality determining step comprises the step of detecting a state of electrification of the heater, and the step of, if it is determined that the oxygen sensor has an abnormality in a situation where the heater is not electrified, identifying the abnormality as an abnormality of the sensor element.

28. The deterioration detection method according to claim 27, wherein the abnormality determining step comprises the step of stopping electrification of the heater if it is determined that the oxygen sensor has an abnormality in a situation where the heater is electrified.

29. The deterioration detection method according to claim 28, wherein the abnormality determining step comprises the step of determining that the heater has an abnormality if determination of an abnormality of the oxygen sensor is overturned after the electrification of the heater is stopped in the stopping step.

30. The deterioration detection method according to claim 25,

wherein the abnormality determining step comprises the step of detecting an amount of change in the first judgment value, and the step of detecting an amount of change in the second judgment value, and

wherein it is determined that the oxygen sensor has an abnormality if the amount of change in the first judgment value and the amount of change in the second judgment value do not exhibit a normal correlation.

31. A deterioration detection method for an oxygen sensor, comprising the steps of:

calculating an element impedance real value from a value related to an electric power supplied to the oxygen sensor, and acquiring the calculated value as a first judgment value;

calculating an element impedance estimated value from a factor that affects a temperature of the oxygen sensor, and acquiring the calculated value as a second judgment value; and

determining whether the oxygen sensor has an abnormality based on the first judgment value and the second judgment value.

32. The deterioration detection method according to claim 31, wherein in the abnormality determining step, it is determined that the oxygen sensor has an abnormality if a difference between the first judgment value and the second judgment value exceeds a predetermined criterion.

33. The deterioration detection method according to claim 32,

wherein the oxygen sensor comprises a sensor element that exhibits a temperature characteristic, and a heater for heating the sensor element, and

wherein the factor that affects the temperature of the oxygen sensor includes at least a factor related to a state of operation of the heater, and

wherein the abnormality determining step comprises the step of detecting a state of electrification of the heater, and the step of, if it is determined that the oxygen sensor has an abnormality in a situation where the heater is not electrified, identifying the abnormality as an abnormality of the sensor element.

34. The deterioration detection method according to claim 33, wherein the abnormality determining step comprises the step of stopping electrification of the heater if it is determined that the oxygen sensor has an abnormality in a situation where the heater is electrified.

35. The deterioration detection method according to claim 34, wherein the abnormality determining step comprises the step of determining that the heater has an abnormality if determination of an abnormality of the oxygen sensor is overturned after the electrification of the heater is stopped in the stopping step.

36. The deterioration detection method according to claim 31,

wherein the abnormality determining step comprises the step of detecting an amount of change in the first judgment value, and the step of detecting an amount of change in the second judgment value, and

wherein it is determined that the oxygen sensor has an abnormality if the amount of change in the first judgment value and the amount of change in the second judgment value do not exhibit a normal correlation.

37. A deterioration detection method for an oxygen sensor, comprising the steps of:

calculating an element temperature theoretical value from a value related to an electric power supplied to the oxygen sensor, and acquiring the calculated value as a first judgment value;

calculating an element impedance estimated value from a factor that affects a temperature of the oxygen sensor, and acquiring the calculated value as a second judgment value; and

determining whether the oxygen sensor has an abnormality based on the first judgment value and the second judgment value.

38. The deterioration detection method according to claim 37, wherein in the abnormality determining step, it is determined that the oxygen sensor has an abnormality if a relationship between the first judgment value and the second judgment value does not agree with a normal temperature characteristic that is exhibited by an element impedance of the oxygen sensor.

39. The deterioration detection method according to claim 38,

wherein the oxygen sensor comprises a sensor element that exhibits the temperature characteristic, and a heater for heating the sensor element, and

wherein the factor that affects the temperature of the oxygen sensor includes at least a factor related to a state of operation of the heater, and

wherein the abnormality determining step comprises the step of detecting a state of electrification of the heater, and the step of, if it is determined that the oxygen sensor has an abnormality in a situation where the heater is not electrified, identifying the abnormality as an abnormality of the sensor element.

40. The deterioration detection method according to claim 39, wherein the abnormality determining step comprises the step of stopping electrification of the heater if it is determined that the oxygen sensor has an abnormality in a situation where the heater is electrified.

41. The deterioration detection method according to claim 40, wherein the abnormality determining step comprises the step of determining that the heater has an abnormality if determination of an abnormality of the oxygen sensor is overturned after the electrification of the heater is stopped in the stopping step.

42. The deterioration detection method according to claim 37,

wherein the abnormality determining step comprises the step of detecting an amount of change in the first judgment value, and the step of detecting an amount of change in the second judgment value, and

wherein it is determined that the oxygen sensor has an abnormality if the amount of change in the first judgment value and the amount of change in the second judgment value do not exhibit a normal correlation.

43. A deterioration detection method for an oxygen sensor, comprising the steps of:

calculating an element temperature theoretical value from a value related to an electric power supplied to the oxygen sensor, and acquiring the calculated value as a first judgment value;

calculating an element temperature estimated value from a factor that affects a temperature of the oxygen sensor, and acquiring the calculated value as a second judgment value; and

determining whether the oxygen sensor has an abnormality based on the first judgment value and the second judgment value.

44. The deterioration detection method according to claim 43, wherein in the abnormality determining step, it is determined that the oxygen sensor has an abnormality if a difference between the first judgment value and the second judgment value exceeds a predetermined criterion.

45. The deterioration detection method according to claim 44,

wherein the oxygen sensor comprises a sensor element that exhibits a temperature characteristic, and a heater for heating the sensor element, and

wherein the factor that affects the temperature of the oxygen sensor includes at least a factor related to a state of operation of the heater, and

wherein the abnormality determining step comprises the step of detecting a state of electrification of the heater, and the step of, if it is determined that the oxygen sensor has an abnormality in a situation where the heater is not electrified, identifying the abnormality as an abnormality of the sensor element.

46. The deterioration detection method according to claim 45, wherein the abnormality determining step comprises the step of stopping electrification of the heater if it is determined that the oxygen sensor has an abnormality in a situation where the heater is electrified.

47. The deterioration detection method according to claim 46, wherein the abnormality determining step comprises the step of determining that the heater has an abnormality if determination of an abnormality of the oxygen sensor is overturned after the electrification of the heater is stopped in the stopping step.

48. The deterioration detection method according to claim 43,

wherein the abnormality determining step comprises the step of detecting an amount of change in the first judgment value, and the step of detecting an amount of change in the second judgment value, and

wherein it is determined that the oxygen sensor has an abnormality if the amount of change in the first judgment value and the amount of change in the second judgment value do not exhibit a normal correlation.